A 48K UPGRADE FOR YOUR ATARI 400

By Claus Buchholz

[Editor's note: Atari Inc. does not recommend that you try the following modification. After all, they don't even acknowledge that a 400 can be upgraded to 32K, much less 48. Need we remind you that actually opening up the case and playing with the insides will void your warranty? This modification is not for the fainthearted or the clumsy--one little Oops! and your 400 is DOA. We at MACE cannot even vouch that the mod works, as we have not ourselves tried to duplicate the author's success.

Nonetheless, we know that among our members there are a few incorrigible hackers who think that hardwired spaghetti improves the machine's asthetic value, as well as some who can't resist a bargain. Although we don't want to encourage you, we would rather have you down in the basement ripping your computer apart than out on the streets where you might do some real harm. So in the interest of public safety, we publish the following article. We suggest you have the Harware manual handy as well, to refer to the schematics and block diagrams. After all, you've got almost $250 invested in your computer!

For the rest of you, you might note that the price of commercial modifications has been coming down as of late. We have just been informed by Cliff Blake of Screensonics that they will install a 48K mod in your 400 for the low price of $159, complete! They will also do GTIA upgrades for $30 installed. They have a huge parts inventory, including all sorts of useful things for hackers, like rolls of nine-conducter cable for the joystick ports, joystick extension cables with molded plugs, 13 pin serial-port connectors for long extensions, aracade type button switches, etc. The address for Screensonics is 14416 S. Outer 40 Road, Chesterfield, MO 63017).]

None of us needs to be reminded of the awesome power of the Atari personal computers. What many fail to realize is that, except for the full-stroke keyboard and greater configurability of the 800, the Atari 400 shares all the power of her big sister. The high performance/price ratio of the 400 makes it a very attractive computer.

The 16K RAM supplied (8K in earlier models), however, is simply inadequate for many users' needs. Atari designed the 400 to address 32K but they don't sell 32K boards. Other manufacturers sell 32K and 48K boards, but their added cost severely decreases the performance/price ratio that distinguishes the 400 from other computers.

I have designed and implemented a 48K upgrade for the 400 that you can add for about $70 and a few hours' work. With 48K, you can run nearly every program written for the Atari computers, including that program you've not finished writing because, "It won't fit!"

The modification is based on the idea of replacing the existing 16K-bit (or 8K) RAM chips with the newer 64K-bit devices. These dynamic RAMs are operationally compatible with the 16K chips. Note the two major differences: The 64K RAMs have an additional multiplexed address pin to access the larger memory. Also, they need only a single 5V power supply as opposed to the 5V, 12V, and -5V supplies which the 16K RAMs use (see Figure 1 for a pinout comparison).

Some circuitry must also be added to allow the 400 to address 48K. Note that the new RAM chips can hold 64K of memory, but the Atari can only address 48K. If you can't bear to waste the extra 16K, see the suggestions later in the article.

The parts listed in the Parts List are available from many mail order houses who advertise in the back of most computer magazines. You will also need a fine-tipped soldering iron, an ohmmeter, small pliers, screwdrivers, solder, fine wir., and a clean and static-free place to work. You should have a little experience in working with electronics. If you don't, find a friend who does and could help you.

The first step is to open your 400. Disconnect all cables. Turn the 400 over and remove the four screws in the underside of the plastic case. While holding the case together, turn it over again. Open the cartidge door and remove any cartridge, leaving the door open. Lift the rear of the top half of the case over the door. To remove the case top from the keyboard, press on the bottom of the keyboard on either side until it bends, and slide the keyboard away from you. The case top should now be free. Now remove the keyboard by pulling straight up on the flexible connector under the right side of the keyboard.

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The circuit board on the right is the power supply. The computer is inside the metal case. Remove the two screws that fasten the left side of the power supply board to the right side of the metal case. Gently but firmly pull up the left front side of the power supply to disconnect it from the main board on the bottom. Be careful of the plastic interlock switch plunger when moving the power supply board. Now remove the speaker connector from the left front of the main board, and lift the metal case out of the plastic case bottom.

Turn the metal case over and remove all the screws and the bottom plate. Now pull the main circuit board up and out of the metal case, taking care not to flex the board. You may have to gently pry the edges to loosen the board from the metal case.

You now see the 400 in its full splendor. Lay the main cicuit board down so the joystick ports face you. The smaller boards sticking up are the memory board and CPU board. The one nearer to you is the memory board. Unplug each, again being careful not to flex the circuit boards. You may also remove the beige plastic piece on the main board by bending its prongs underneath the board.

Look at the CPU board. It has three large chips. The middle one is the CTIA or GTIA. If you want to replace your CTIA with a GTIA, now is the time to do it. See the feature article in the March, 1982, issue for instructions. The CPU board is not altered in this memory upgrade, so put it away.

Look at the memory board. The eight chips along the top are the RAM chips. The other four chips are the addressing circuitry. The edge pin connectors at the bottom are labeled as in Figure 2. If you have an 8K 400, you must alter the memory board before proceeding with the upgrade. Instructions for this modification appear at the end of the article.

The first step in the 48K modification is to eliminate the 12V and -5V sources on the board and move the 5V source to where 12V used to be. As shown in Figure 3, cut the trace going from pin X of the board's edge connector to the capacitor C521. Also cut the trace going from edge pin Y to C523. Cut the traces cleanly and completely. Be careful not to slip and damage adjacent traces.

Now remove the capacitors C521 and C523. The trace coming from pin W carries 5V. Using a short piece of wire, make a solder bridge between this trace and the old 12V trace, at the point where C523 used to be (see Figure 3). Next, remove the eight capacitors C503, C505, C507, C509, C511, C513, C515, and C517, which are usually in a row along the top of the board.

We now have 5V going to pins 8 and 9 of the RAM chips, and no connection to pin 1. Remove the eight RAM chips and insert the 64K RAMs in their place, properly orienting the notched ends. With an ohmmeter, make sure there is no connection between edge pin X and pin 1 of the RAM chips. There should also be no connection between edge pin Y and pin 8 of the chips, nor should there be any connection between any two of the edge pins W, X, and Y.

If all has gone well, the board should be functioning exactly like a 16K memory board, since the addressing circuitry has not yet been altered. Now may be a good time to test the board (particularly the new RAM chips). If you wish, reassemble the entire computer and check to see if it works properly as a 16K 400. If it doesn't work, recheck all connections and disconnections made so far.

Now take the 5V supply off pin 9 of the RAM chips. To do this, cut the rightmost wide trace on the chip side of the board (see Figure 4).

Pick up the 74LS158 chip, which is the same as the chips Z503 and Z504 on the memory board. With needlenose pliers, carefully bend up all the pins except 1, 8, 15, and 16 (see Figure 5). The remaining four pins are to be soldered onto the chip Z503. Remove the chip at Z503 from its socket and place the 74LS158 on top so that the four pins listed above touch the same four pins on the lower chip (as in Figure 5). Carefully solder each of the four pair of pins together, being careful not to get too much solder on the end of each pin.

Now solder a 4" length of wire to each of the pins 2, 3, and 4 of the top chip. Reinsert the chip pair at Z503. Solder the wire from pin 2 into the hole attached to edge pin M, and the wire from pin 3 to edge pin U. Next solder the

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wire from pin 4 to a hole in the former 5V bus, the wide trace along the top of the chip side of the board.

The memory board is now complete. With an ohmmeter, check all connections diagrammed in Figure 6.

The final stage involves modifiying the main (mother) board itself. To help you visualize this stage better, I have included a partial schematic in figure 7, and a pin diagram in figure 7a. Locate chip Z103 forward of the memory slot (see figure 7a). On the underside of the board, cut the traces leading from pins 1 and 2 of Z103. Now attach a wire from pin 24 (across from pin BB) on the underside of the CPU board slot to pin U under the memory slot. Attach a second wire from pin CC under the CPU slot to pin M under the memory slot.

Now wire the circuit of Figure 7, using the pin diagram of figure 7a. On the 14-pin socket, solder pins 3 and 4 together with a short piece of bare wire. Do the same with pins 2 and 13. Next solder an 8" length of wire to each of the pins 1, 5, 6, 7, 11, 12, and 14. With these wires, make the six connections to the underside of the cartridge slot as diagrammed. The seventh wire from pin 1 goes to pin 18 on the underside of the memory slot.

Plug the 74LS02 into the socket and bend the wires around some notches on the edge of the main board so as to position the chip above the board, between the crystal and cartridge slot. Finally, solder one of the 680 ohm resistors between pin A under the cartridge slot and the nearest ground connection. Be especially careful that excess solder does not form "bridges", making electrical connection where none should exist. Put the second resistor between ground and pin 14 under the cartridge slot.

The modification is finished. Recheck all connections, as an improper connection may damage the computer. Reassemble the computer, being careful that the 74LS02 chip doesn't touch any other circuitry. It's a good idea to wrap the chip in some electrical tape.

Plug in the 400 and turn it on. If the blue screen doesn't come up quickly, turn it off immediately and check that your work, including reassembly, has been done correctly. If you have exercised proper care, you should now have 48K of RAM for your 400. Enjoy.

MODIFYING AN 8K BOARD

Near the center of the board are six pair of holes, marked A through F in which two resistors reside. Remove both resistors. If one of them is at C, leave it there. Otherwise, solder one of the removed resistors at C. Now solder a wire from edge connector pin H to the trace that connects holes D, E, and F together.

Next, cut the trace leading to pin 13 of the chip at Z501, and solder a wire from this pin to edge connector pin U. The board is now ready to be modified for 48K as described above.

SUGGESTIONS FOR A 64K MODIFICATION

Figure 8 shows a circuit that will allow you to access the unused 16K on your modified board. After you have successfully completed the 48K modification as described above, disconnect the wire you put between edge pin U and pin 3 of the 74LS158. Wire the circuit of Figure 8 in its place.

Two more chips are needed for this circuit, a 74LS00 quad NAND gate, and a 74LS74 dual flip-flop. They may be wired to the memory board using sockets as you did with the 74LS02. The NOR gate on the left is from the 74LS02 chip you wired to the main board. You may bring its output to the memory board through an unused edge pin such as pin V.

The extra 16K is bank switched with the middle 16K of the 48K RAM. By writing a 1 to a memory location between D700 and D7FF (55040 to 55295 decimal), you replace the middle 16K of your 48K with a new bank of 16K. When you write a 0 to the same location, you get the original bank back. This is best done in machine language, since you can confuse BASIC by switching out part of a BASIC program.

Although you must be careful in using this extra 16K, it can come in very handy for storing extra graphics screens or other kinds of data. I have not yet implemented this 64K modification, so I leave it to the more adventuresome of you to build, test, and use.

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FINAL NOTES

When a cartridge is inserted into the 400, the addressing circuitry disconnects the top 8K of RAM. For example, with the BASIC cartridge you have only 40K of RAM. This is normally the case with the 800. If Atari ever comes out with a 16K ROM cartridge, it will properly disable the top 16K of RAM when inserted.

Remember that performing this modification will void any warranty remaining on your 400. If you just can't get the modification to work, you may repair all the cut traces, remove added circuitry, and reinsert the orginal RAM chips to restore your 400 to its original condition, assuming nothing was damaged.

PARTS LIST

QTY	ITEM
8	4164 200 nanosecond dynamic RAM
1	74LS158 quad 2 to 1 multiplexer
1	74LS02 quad NOR gate
2	680 ohm 1/2 watt resistor
1	14-pin DIP soldertail socket

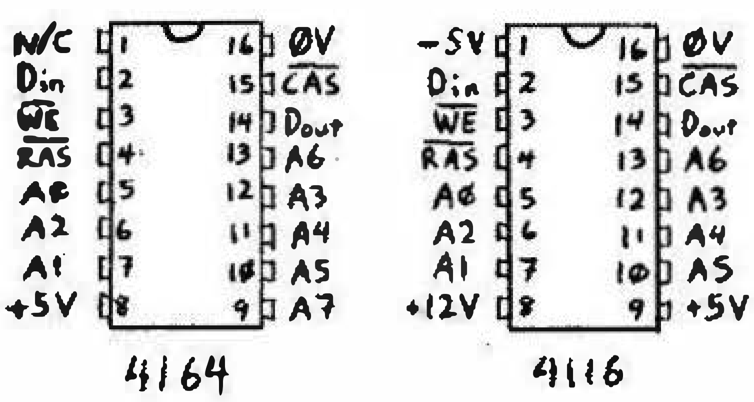

Fig. 1 - Pinout comparison of 64K- and 16K-bit RAMs

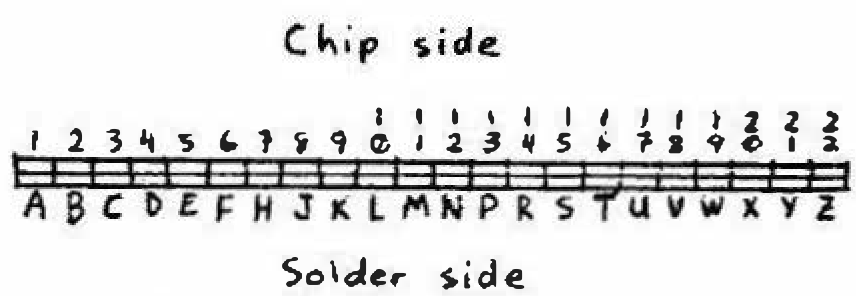

Fig. 2 - Connector identification for memory board, seen from below

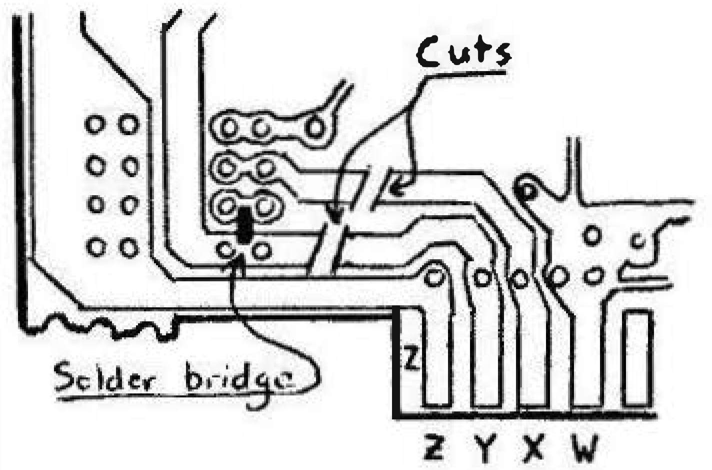

Fig. 3 - Lower left corner of solder side of memory board

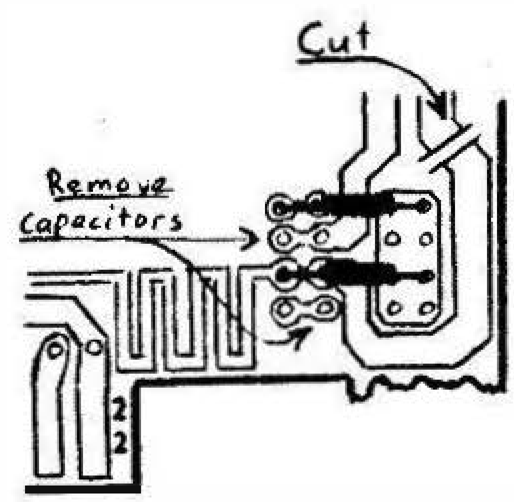

Fig. 4 - Lower right corner of chip side of memory board

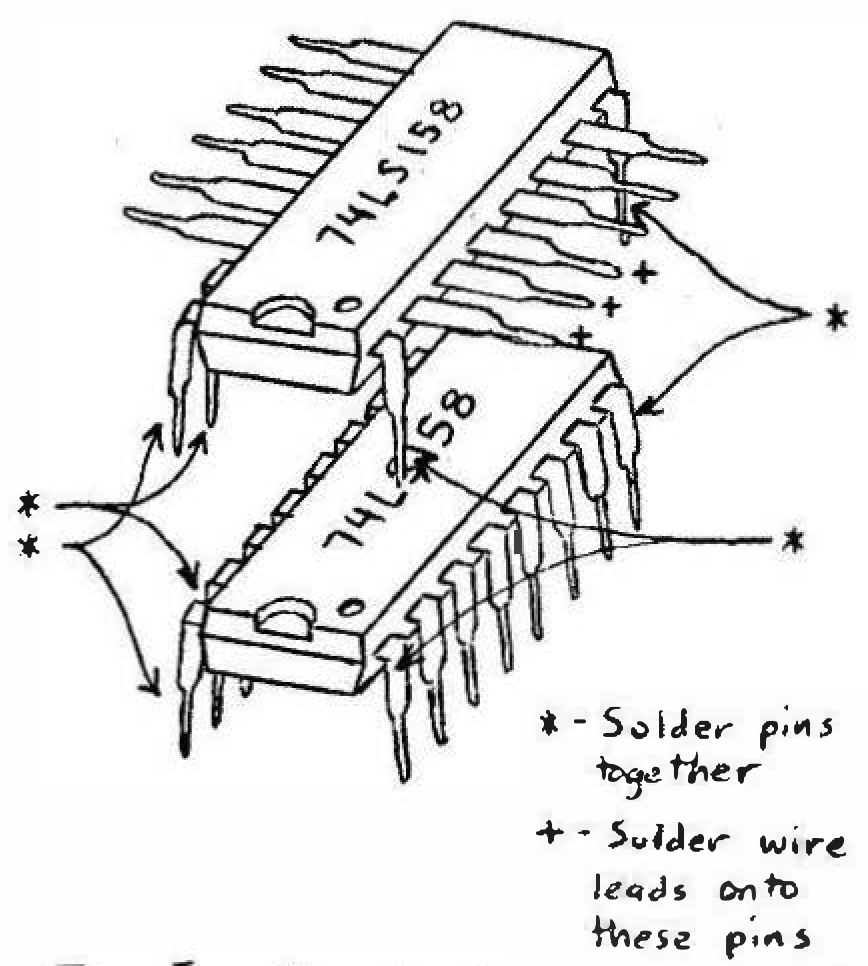

Fig. 5 - Piggyback arrangement

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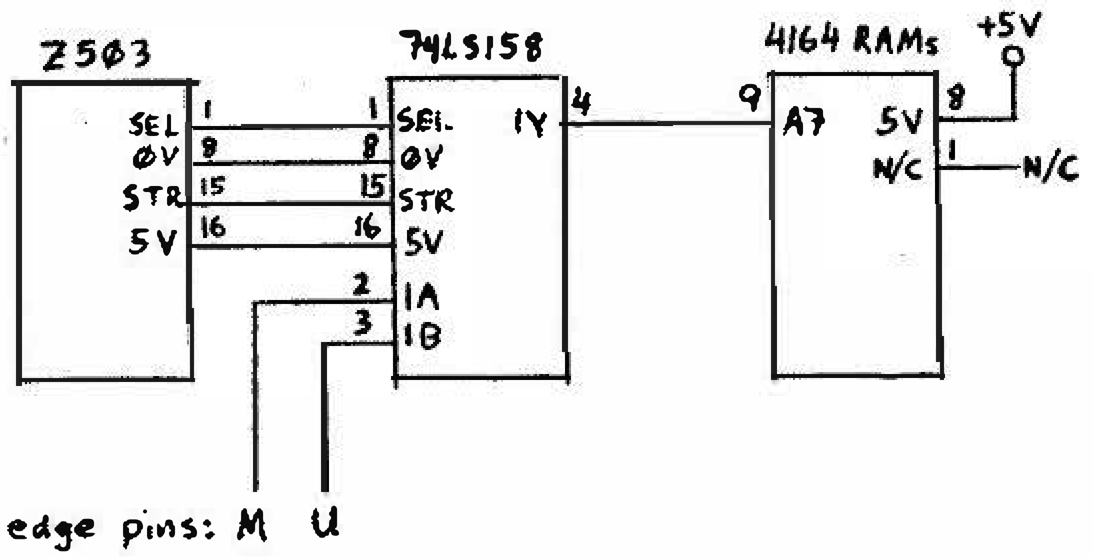

Fig. 6 - Schematic for memory board modification

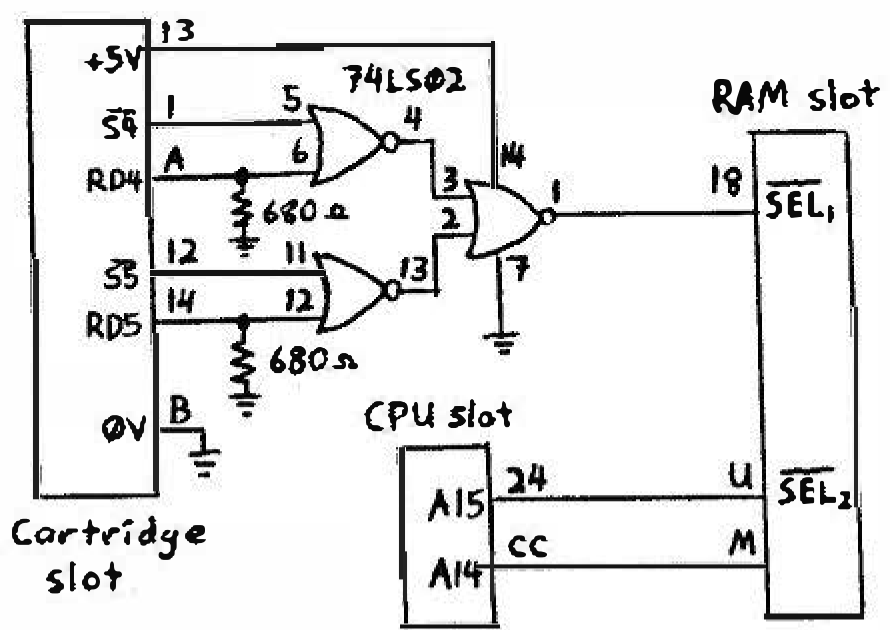

Fig. 7 - Schematic for main board modification

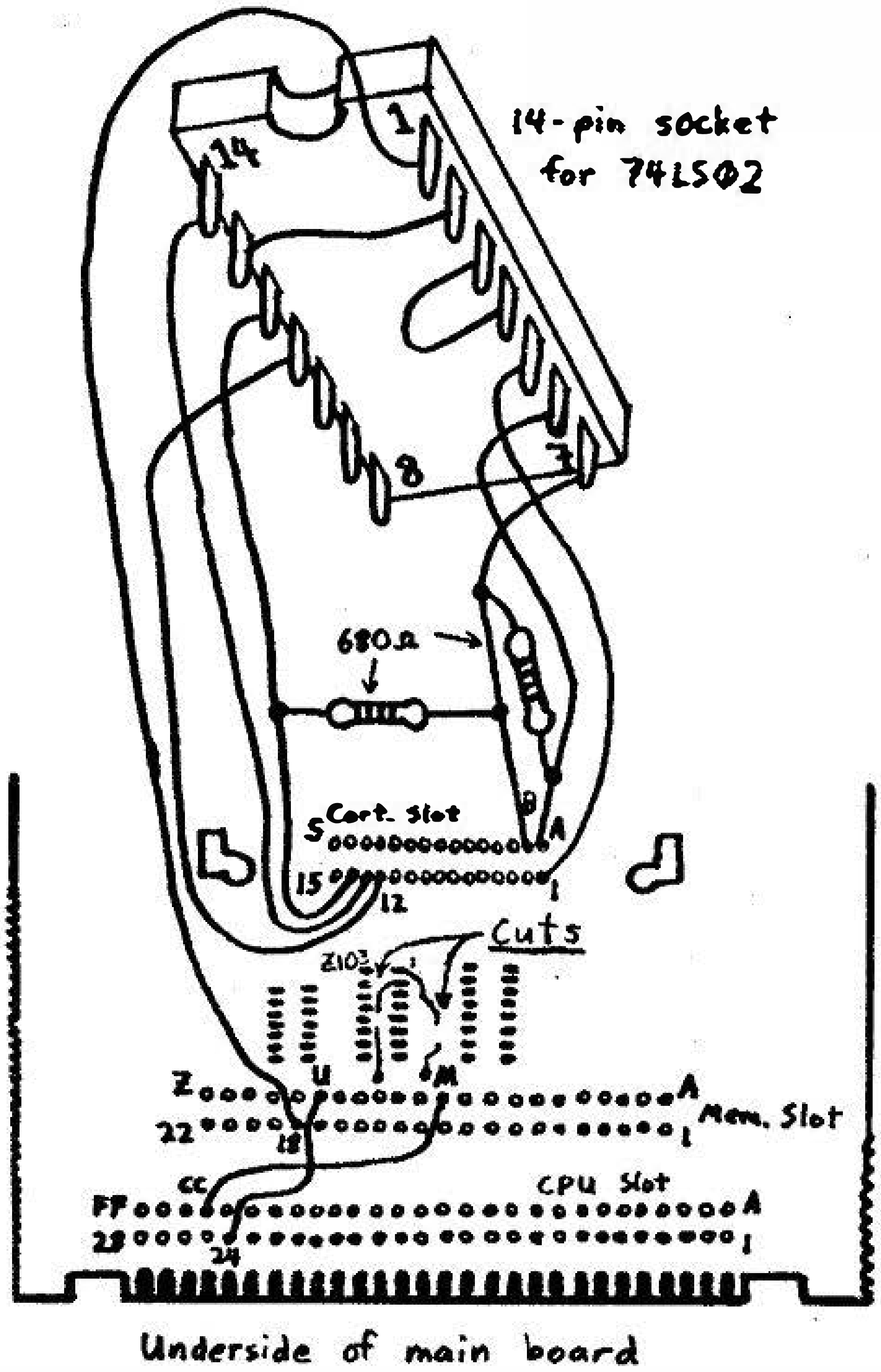

Fig. 7a - Connections for main board modifications

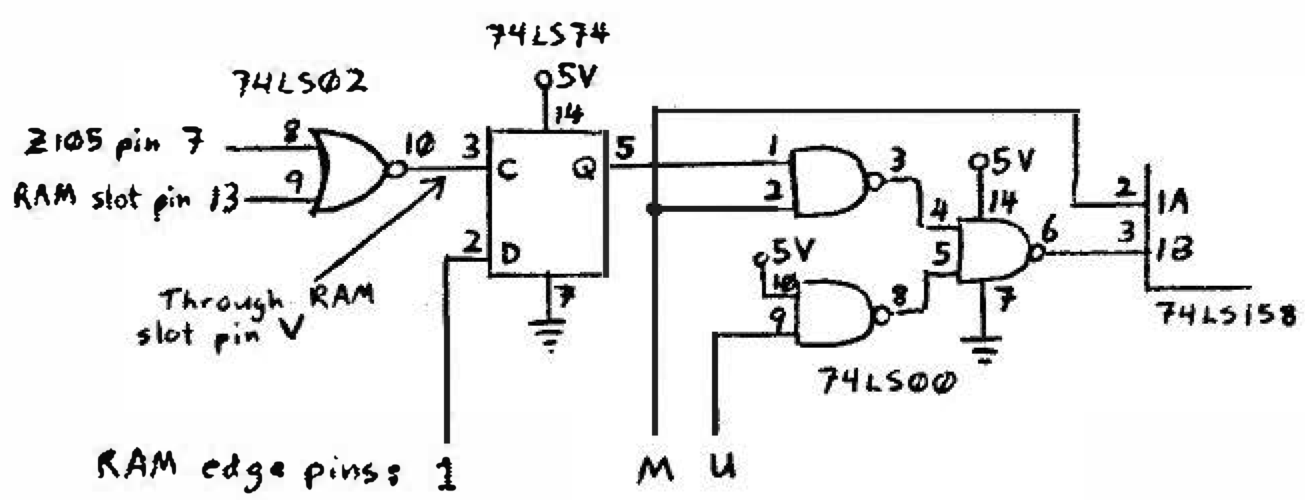

Fig. 8 - Schematic for 64K modification